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Rock Slope Monitoring from 4D Time-Lapse Structure from Motion Analysis

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Structure from Motion (SfM) photogrammetry has become an important tool for studying earth surface processes because of its flexibility, ease of use, low cost and its capability of producing high quality 3-D surface models. A major benefit of SfM is that model accuracy is fit for purpose and surveys can be designed to meet a large range of spatial and temporal scales. In the Earth sciences, research in time-lapse SfM photogrammetry or videogrammetry is an area that is difficult to undertake due to complexities in acquiring, processing and managing large 4D datasets and represents an area with significant advancement potential (Eltner et al. 2016).

In this study, we investigate the potential of 4D time-lapse SfM to monitor unstable rock slopes. We tested an array of statically mounted cameras collecting time-lapse photos of a limestone rock slope located along a highway in Canada. Our setup consisted of 8 DSLR cameras with 50 mm prime lenses spaced 2-3 m apart at a distance of 10 m from the slope. The portion of the rock slope monitored was 20 m wide and 6 m high. We collected data in four phases, each having 50 photographs taken simultaneously by each camera. The first phase of photographs was taken of the stable slope. In each successive phase, we gradually moved small, discrete blocks within the rock slope by 5-15 mm, simulating pre-failure deformation of rockfall. During the last phase we also removed discrete rock blocks, simulating rockfall.

We used Agisoft Photoscan's 4D processing functionality and timeline tools to create 3D point clouds from the time-lapse photographs. These tools have the benefit of attaining better accuracy photo alignments as a greater number of photos are used. For change detection, we used the 4D filtering and calibration technique proposed by Kromer et al. (2015), which takes advantage of high degrees of spatial and temporal point redundancy to decrease measurement uncertainty. Preliminary results show that it is possible to attain more accurate 3D models using time-lapse photos taken from an array of cameras than photos taken from a single camera from multiple positions. For this survey setup, it was possible to detect mm to cm level of changes, which is of sufficient accuracy to detect the pre-failure stage of rockfalls, as well as small rockfall events. Additionally, cameras mounted in a static array can be operated remotely and automatically. Time-lapse SfM photogrammetry can be a cost effective alternative to terrestrial laser scanning for rockfall prone areas and facilitates the study of surface processes with high spatial and temporal detail.

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References

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